EFFECTS OF MESSENGER™ ON COTTON GROWN IN THE FIELD AND UNDER CONTROLLED CONDITIONS

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Abstract

Messenger™ is the first of a new class of crop protectants which contain the active ingredient, harpin. Harpin, an extracellular protein isolated from bacterial plant pathogens, activates a plant's natural defense mechanisms by inducing systemic acquired resistance (SAR), thus providing resistance to a broad range of diseases and pests. Preliminary trials have shown that cotton (*Gossypium hirsutum* L.)yield might be improved with foliar applications of Messenger™ . In 2000, two field studies were conducted in eastern Arkansas to determine the effects of Messenger™ on cotton yields. In field study 1, treatments consisted of an untreated control, seed treatment (2 oz/100 lb seed), foliar treatment (2.23 oz/acre),and seed + foliar treatment. In study two, treatments consisted of an untreated control and seven foliar treatments at a rate of 2.23 oz/acre applied at various timing intervals. No significant differences in yield were encountered between treatments at either location. Widespread potassium deficiencies were observed at both locations. It is possible that the excessively hot, dry conditions along with the nutrient deficiencies, masked potential yield increases in the field. A growth chamber study was conducted to investigate the effects of Messenger™ under controlled conditions. Treatments consisted of two rates: 2.23 and 4.46 oz/acre, and two timings of Messenger™ application: beginning at 2nd true-leaf and pinhead square. While no significant differences were observed in physiological parameters, treated plants had significantly more nodes and squares at first-flower, suggesting that Messenger™ enhanced cotton growth and yield potential.

Introduction

Over the last few decades, concern for the protection of the environment has escalated. This has inspired agricultural researchers to develop non-toxic crop protectants, often borrowing from nature itself. One such product is Messenger™ (Eden Bioscience, Seattle, WA), which contains the protein, harpin, isolated from bacterial plant pathogens. The protein is responsible for inducing a plant's natural defense mechanism. Messenger™ has shown success in a variety of crops, including tomato (*Lypersicon esculentum* L.) and wheat (*Triticum aestivum* L.) in regards to pest management and yield enhancement. Preliminary studies have shown that Messenger™ may improve yields in a variety of crops including cotton (Wright et al., 2000) The objectives of these studies were to evaluate the effects of seed treatment and foliar applications of Messenger™ on cotton yield and physiology.

Materials and Methods

Field Study 1

This field study was conducted at the Delta Branch Station in Northeast, Arkansas. Six replications of Sure-Grow 747 were planted into a randomized complete block design on May 16, 2000. Pest control, irrigation, and fertilizer management were according to Arkansas cotton production recommendations. Plots consisted of 4 rows, 50 feet in length spaced 36 inches apart. Foliar sprays using deionized water were applied with a CO_2 backpack sprayer calibrated to deliver 10 gallons of solution/acre. The treatments were as follows: 1) untreated control; 2) seed treatment: 2 oz/100 lb seed at planting; 3) foliar treatment: 2.23 oz/acre at 1st true leaf (TL), pinhead square (PHS), first-flower (FF), and FF + 2 weeks; 4) seed and foliar treatment (treatments 2 & 3). Leaf nutrient concentrations of N, P, K, Ca, Fe, Mg, and Zn were determined at FF, FF + 2 weeks, and FF + 6 weeks from fifteen leaves per plot collected between 9 and 10 am in the morning. Photosynthesis and stomatal conductance was measured at FF + 2 weeks with a LI-COR-6200 portable photosynthesis system. Yield was determined from the inside two rows of each plot with a mechanical picker. Boll numbers, boll weights and fiber quality were assessed by hand-harvesting 2 m^2 of row per plot.

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Field Study 2

This field study was conducted at the Bryant farm in Eastern, Arkansas. Six replications of Delta Pine 451BR were planted into a randomized complete block design on May 9, 2000. Pest control, irrigation, and fertilizer management were according to the producers standard practices. Foliar sprays using deionized water were applied with a CO_2 backpack sprayer calibrated to deliver 10 gallons of solution/acre. A rate of 2.23 oz/acre of Messenger™ was used for all foliar sprays. Treatments were as follows:

1. Untreated control
2. 2nd TL, PHS, PHS + 2 weeks, FF, FF + 3 weeks
3. 2nd TL, PHS, PHS + 2 weeks
4. 2nd TL, PHS, FF
5. 2nd TL, PHS, PHS + 2 weeks, FF
6. PHS, FF, FF + 3 weeks
7. PHS, PHS + 2 weeks, FF, FF + 3 weeks
8. 2nd TL , FF, FF + 3 weeks

Leaf nutrient concentrations of N, P, K, Ca, Fe, Mg, and Zn were determined at FF and FF + 6 weeks from fifteen leaves per plot collected between 9 and 10 am in the morning. Yield was determined from the inside two rows of each plot with a mechanical picker. Boll numbers, boll weights, and fiber quality were assessed by hand-harvesting 10 feet.

Growth Chamber Study

A growth chamber study was conducted at the Altheimer laboratory in Fayetteville in the spring of 2000 to determine the effects of Messenger™ on the physiology of cotton. Sure-Grow 125 was planted in 2 L pots containing Sunshine mix, a soilless horticultural blend, and arranged in a completely randomized design. All pots were watered with half-strength Hoagland's nutrient solution to maintain a well-watered status. Treatments consisted of 2 rates, 2 timings, and an untreated control sprayed with deionized water only. Rates were 2.23 and 4.46 oz/acre, and sprays began at the 2nd true leaf, or at PHS and continued weekly through PHS + 2 weeks. At FF, the following measurements were taken: Leaf photosynthetic rate, chlorophyll (SPAD Index), membrane integrity, and above-ground biomass.

Results

Yield components for the field studies are shown in Table 1 (field study 1) and Table 2 (field study 2). No significant differences between treatments were encountered in yield components in either study. No significant differences in physiological data were seen at FF + 2 weeks in study one (Table 3). Leaf nutrient analyses (data not shown)revealed potassium deficiencies throughout flowering and boll development in both field studies. The mean potassium tissue concentration was 0.92 percent in study 1 (Delta Branch Station), and 1.17 percent in study 2 (Bryant Farm). In study 1, zinc concentrations fell to 15.9 ppm at FF + 2 weeks, with 15 to 20 ppm being the marginal range for zinc at this stage of cotton development. All other measured nutrients were in adequate concentrations throughout the sampling period.

In the growth chamber, no significant differences between treatments existed in physiological data (Table 4). While no significant differences existed between treated and untreated plants in regards to plant height, plants treated with 4.46 oz/acre beginning at PHS had more main-stem nodes when compared to the untreated control plants (Table 5). Significant differences were also evident in the number of squares, as both treatments receiving 4.46 oz/acre had significantly more squares compared to the untreated control plants.

Conclusions

The Messenger™ trials described in this paper did not result in significant yield or physiological differences. Both potassium and zinc are important in cotton fruit set and development, and it is possible that these deficiencies in the field studies, along with the extreme heat and drought conditions, masked any potential yield differences. The significant differences in number of nodes and squares in the growth chamber were a good indication that Messenger™ can enhance cotton growth and yield potential. Because many factors determine final yield, the evaluation of an agricultural product should include results from several field seasons. Research will be continued to determine if Messenger™ can enhance cotton yields.

References

Wright, D. L., P. J. Wiatrak, S. Grzes, and J. Pudelko. 2000. Messenger: A systemic acquired resistance influence on cotton. Pp. 617-619. *In:* P. Dugger and D.A. Richter (eds). Proc. Beltwide Cotton Conference. National Cotton Council, Memphis, Tennessee.

Table 1. Yield components at time of harvest in field study 1 (northeast Arkansas).

Treatment	Lint (kg/ha)	Turnout (%)	Open Bolls (#/m^2)	Boll Weight (g/boll)
Untreated Control	1658	40.5	82	5.0
Seed Treatment	1671	40.1	81	5.1
Foliar Treatment	1690	40.8	86	4.8
Seed + Foliar Treatment	1744	42.9	86	4.8
LSD (p=0.05)	NS	NS	NS	NS

Table 2. Yield components at time of harvest in field study 2 (eastern Arkansas).

Treatment	Lint (kg/ha)	Turnout (%)	Open Bolls (#/m^2)
Untreated Control	1027	38.1	59
2nd TL PHS PHS+2 weeks FF FF + 3 weeks	974	37.9	39
2nd TL PHS PHS+ 2 weeks	1014	37.6	58
2nd TL PHS FF	996	37.1	43
2nd TL PHS PHS+ 2 weeks FF	961	38.1	58
PHS FF FF+ 3 weeks	970	37.5	42
PHS PHS+ 2 weeks FF FF + 3 weeks	1033	38.0	63
2nd TL FF FF + 3 weeks	1009	37.6	43
LSD (p=0.05)	NS	NS	NS

Table 3. Physiological data at FF + 2 weeks in field study 1 (northeast Arkansas).

Treatment	Photosynthesis (µmol/cm^2/sec)	Stomatal Conductance (mol/m^2/sec)
Untreated Control	32.3	4.04
Seed Treatment	33.8	4.07
Foliar Treatment	29.2	4.16
Seed + Foliar Treatment	32.1	4.35
LSD (p=0.05)	NS	NS

Table 4. Growth chamber physiological data collected at FF (Fayetteville, Arkansas).

Treatment	Photosynthesis (µmol/cm^2/sec)	Chlorophyll (SPAD Index)
Untreated Control	18.2	41.7
2.23 oz/acre 2nd TL	20.2	41.2
2.23 oz/acre PHS	18.1	42.4
4.46 oz/acre 2nd TL	19.7	41.3
4.46 oz/acre PHS	20.8	41.4
LSD (p=0.05)	NS	NS

Table 5. Growth chamber growth analysis data collected at FF (Fayetteville, Arkansas).

Treatment	Height (cm)	Nodes (#)	Squares (#)
Untreated Control	77.5	12.6	6.3
2.23 oz/acre 2nd TL	75.2	12.4	5.6
2.23 oz/acre PHS	78.8	13.2	8.8
4.46 oz/acre 2nd TL	78.8	13.4	108
4.46 oz/acre PHS	79.6	13.6	10.4
LSD (p=0.05)	5.7	0.9	3.48